Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

A99.9
F764U
67.2

SELECTING CRAWLER SKIDDERS BY COMPARING RELATIVE OPERATING COSTS

PAUL L. SCHILLINGS

SOUTHERN FOREST FIRE LABORATORY
P.O. BOX 1748
ATHENS, GEORGIA
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
SD 62 .U0

USDA Forest Service
Research Paper INT-59, 1969

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Ogden, Utah

USDA Forest Service
Research Paper INT-59
1969

SELECTING CRAWLER SKIDDERS BY COMPARING RELATIVE OPERATING COSTS

Paul L. Schillings

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U.S. Department of Agriculture
Ogden, Utah 84401
Joseph F. Pechanec, Director

THE AUTHOR

PAUL L. SCHILLINGS is a research engineer headquartered in Bozeman, Montana, at the Station's Forestry Sciences Laboratory, maintained in cooperation with Montana State University. During the past 4 years he has been engaged in systems studies of logging operations in the Northern Rocky Mountain area.

PREFACE

A preliminary draft of this report was distributed among 50 representatives of the logging industry in the Northern Rocky Mountain and Southeastern States. They were asked to compare known skidding costs with costs estimated by using the charts in this report. Thirty-six responded that they considered their comparisons to be either "reasonable," "useful," or "worthwhile." No negative replies were received; in fact, 30 of the respondents requested similar information for larger tractors. (See Research Paper INT-60 titled "A Technique for Comparing the Costs of Skidding Methods.") This encouraging response was a motivating factor in our decision to publish this report.

However, the author recognizes that wage increases, material changes, and effects of other economic considerations, such as inflation, have occurred since the data for this report were collected. Therefore, the values shown in the six charts (figures 1-6) probably will have to be adjusted to reflect these increases--in some cases, by as much as 12 percent. If a contractor has not kept cost records, it is recommended that he increase the skidding costs found in the charts by at least 10 percent. If he has maintained a cost accounting system and knows his crawler skidding costs, they may be compared with costs selected from the charts provided operating conditions are similar. After a few trial comparisons, the amounts to adjust chart costs may be made on an individual basis with the preceding remarks as a guide.

CONTENTS

Page

Preface iii
Introduction 1
How to Use Skidding Cost Charts 1
Operating Alternatives 9
Appendix 15
  Cycle Time 17
  Controlling Variables 19
  Hourly Owning and Operating Costs . . 19
  Constructing the Charts 19

Figure 1.--Skidding cost chart for crawler class 25-40 DBHP with one-man crew. . . 3
Figure 2.--Skidding cost chart for crawler class 41-60 DBHP with one-man crew. . . 4
Figure 3.--Skidding cost chart for crawler class 61-80 DBHP with one-man crew. . . 5
Figure 4.--Skidding cost chart for crawler class 25-40 DBHP with two-man crew. . . 6
Figure 5.--Skidding cost chart for crawler class 41-60 DBHP with two-man crew. . . 7
Figure 6.--Skidding cost chart for crawler class 61-80 DBHP with two-man crew. . . 8
Figure 7.--Skidding costs under three types of operating conditions with one-man crew, as defined on page 9 11
Figure 8.--Skidding costs under three types of operating conditions with two-man crew, as defined on page 9 12
Figure 9.--Skidding costs under average operating conditions with both one-man and two-man crews, as defined on page 9 13
Figure 10.--Skidding costs under three types of operating conditions with both one-man and two-man crews, as defined on page 10. 14
Figure 11.--Flow diagram of cycle time elements 16

INTRODUCTION

This report is separated into three major sections: (1) working charts, which enable a user to estimate crawler skidding costs per thousand board feet ($/MBF) whenever it is possible to judge skidding distance, terrain type, slope, and operator efficiency; (2) individual graphs giving comparisons and break-even points for various crawler sizes, crew combinations, and operating conditions; and (3) an appendix, which describes how data were gathered and converted to chart presentation.

Data were gathered in the Gallatin, Helena, and Beaverhead National Forests; therefore, the cost estimates should be most accurate for operations in the Northern Rocky Mountain area. This is not to imply that the estimates cannot be used for operations in other areas. Regardless of the area, the following restrictions will hold:

1. Volumes per logs should run from 60 to 140 board feet.

2. Log lengths should be 40 feet or less.

3. The crawler tractors used should fall within the limits of 25 to 80 drawbar horsepower (DBHP).

4. A skidder operator should set his own chokers, or one choker setter should set them for him.

HOW TO USE SKIDDING COST CHARTS

Figures 1 through 6 are the working charts. Basically they are similar; skidding costs are found by following the same procedures on each. A user must select the chart to use by matching crawler classes and crew situations to those of his operations.

To enter any chart he has selected the user must know:

1. The approximate distance in feet from the deck to the general area where logs are hooked. This distance may be paced. After a few "walks" it is surprising how accuracy increases. Be sure to estimate the true skidding distance and not the line-of-sight distance. When the distance changes about 100 feet to a different general area, a new distance should be measured. At the end of a day, week, or other time period, an average is taken of the $/MBF altered by changes in skidding distances. The averaged cost is used over the particular time period observed.

2. The type of terrain in which the crawler must operate. At the top of each chart is a key showing three terrain classifications. In the first graph of each chart, terrain classes 2 and 3 overlap. The right border of the class 2 wedge runs down the middle of the class 3 wedge, and the left border of the class 3 wedge runs down the center of the class 2 wedge. Use of the terrain classifications will be explained in an example later. As terrain classes change, costs are averaged to get a final $/MBF (see requirement 1 above).

3. The average slope in percent over the skidding path. A slope key is shown directly under the terrain key on each chart. The bold vertical lines in the slope key designate a typical section of the terrain wedges shown in the top graph of each chart. If the slope is judged to be 15 percent or less, a point on the left border of the wedge is chosen; if 22 percent, a point in the center of the wedge is chosen; and if 30 percent or greater, a point on the right border of the wedge is chosen. Should the slope fall within the range of 16 to 29 percent, an interpolation is made inside the wedge. The percent of slope may be found with the help of an inexpensive clinometer, or it simply can be estimated. When a slope is negative, that is, going downhill to the viewer, the minus sign is disregarded; only the absolute value is needed. If slopes change about 5 percent through a time period, new readings should be obtained to reach an average cost as before.

4. The tractor operator's efficiency. An operator's efficiency must be judged by comparing his output with that of other operators. Logging contractors have been found to be good judges of the capabilities of their workers. If a man is new on the job and inexperienced, he usually rates in the lower half of a "below average" wedge (see the second or operator efficiency graph on any chart). Notice that the operator efficiency graph allows for the possibility that an operator might be twice as good or twice as bad as another.

A typical path for entering the charts is traced on figure 1 (see superimposed bold dots) as an example. Here the tractor size is small--between 25 and 40 DBHP--and the operator sets his own chokers. In this example, the contractor estimates the distance from deck-to-log area to be 580 feet, terrain conditions best fit class 3, a clinometer shows the slope to average about 28 percent, and the operator is believed to be average based on his production.

Begin at the top graph and follow the dotted path. Run horizontally across from 580 feet using the grid lines as guides and enter terrain class 3. The slope key shows that the right half of a class contains slopes from 22 to 30 percent; hence, interpolate 28 percent just short of the 30 percent bold line on the right border of the terrain class 3 wedge. Drop straight down parallel with grid guide lines into the graph directly below and stop in the middle of the "average" wedge. At this stage, the four estimated factors have been accounted for. Now cross over to the adjoining graph and stop at a point corresponding to that point in the previous graph: from the center, in this example, of the white wedge in the second graph to the center of the white wedge in the third graph. From this point follow the grid lines down into the bottom graph, stopping at the "average" line for hourly owning and operating costs. If records are kept of owning and operating costs, choose a point closest to your figure--interpolate if necessary--instead of using the "average" cost line. Now, go horizontally across to the right axis and pick off the skidding cost estimate. In this example, this estimate approximates $7.50/MBF.

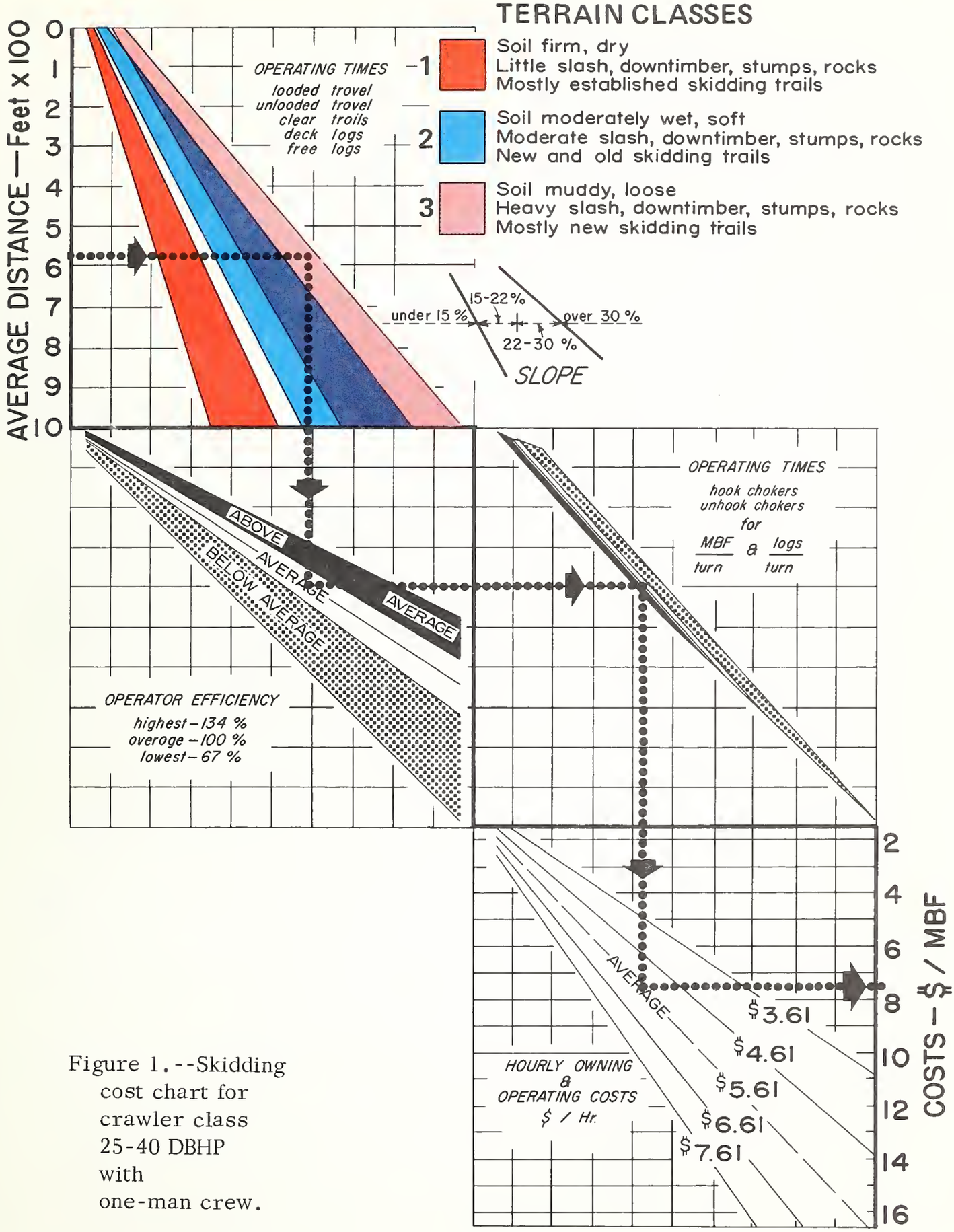

Figure 1.--Skidding cost chart for crawler class 25-40 DBHP with one-man crew.

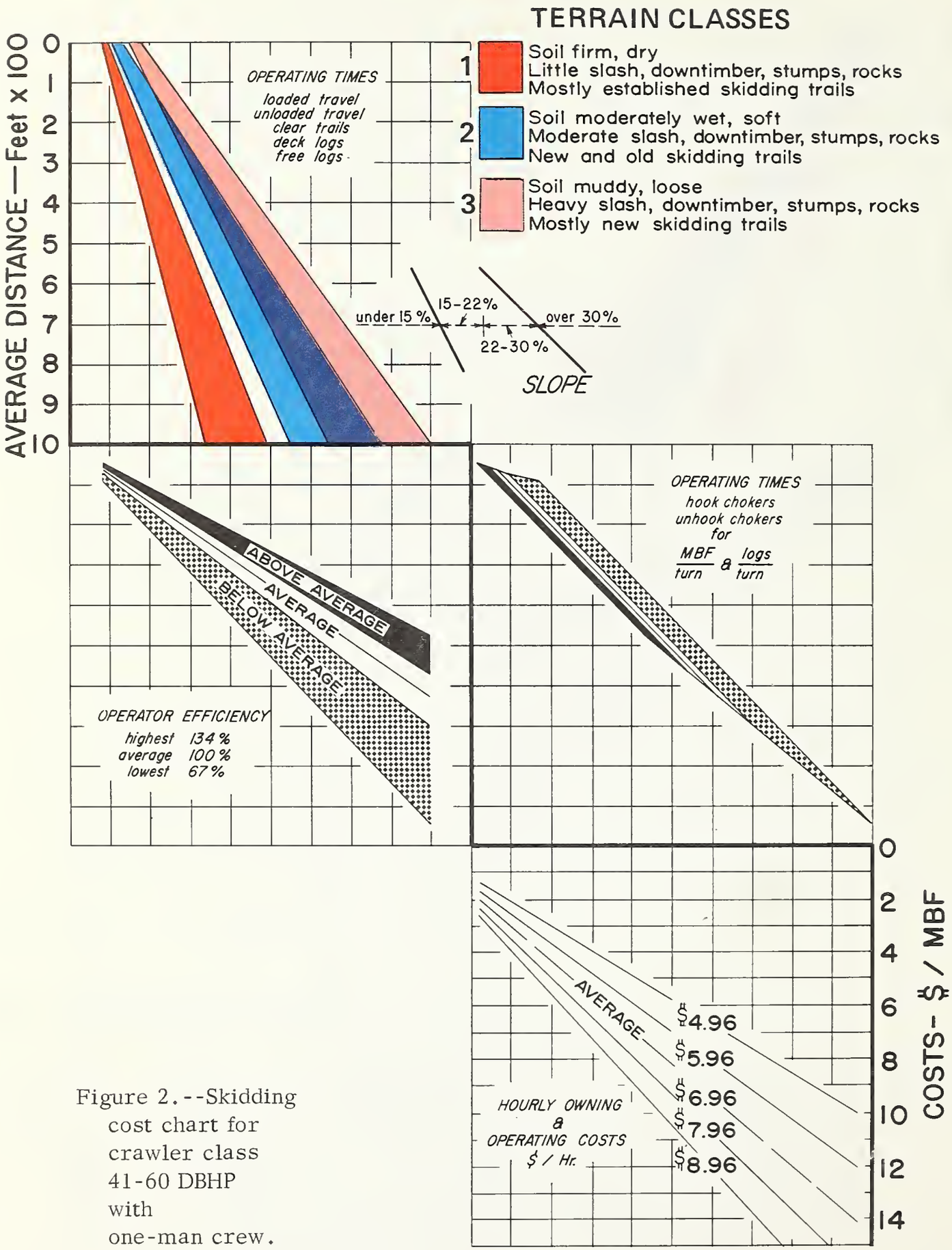

Figure 2.--Skidding cost chart for crawler class 41-60 DBHP with one-man crew.

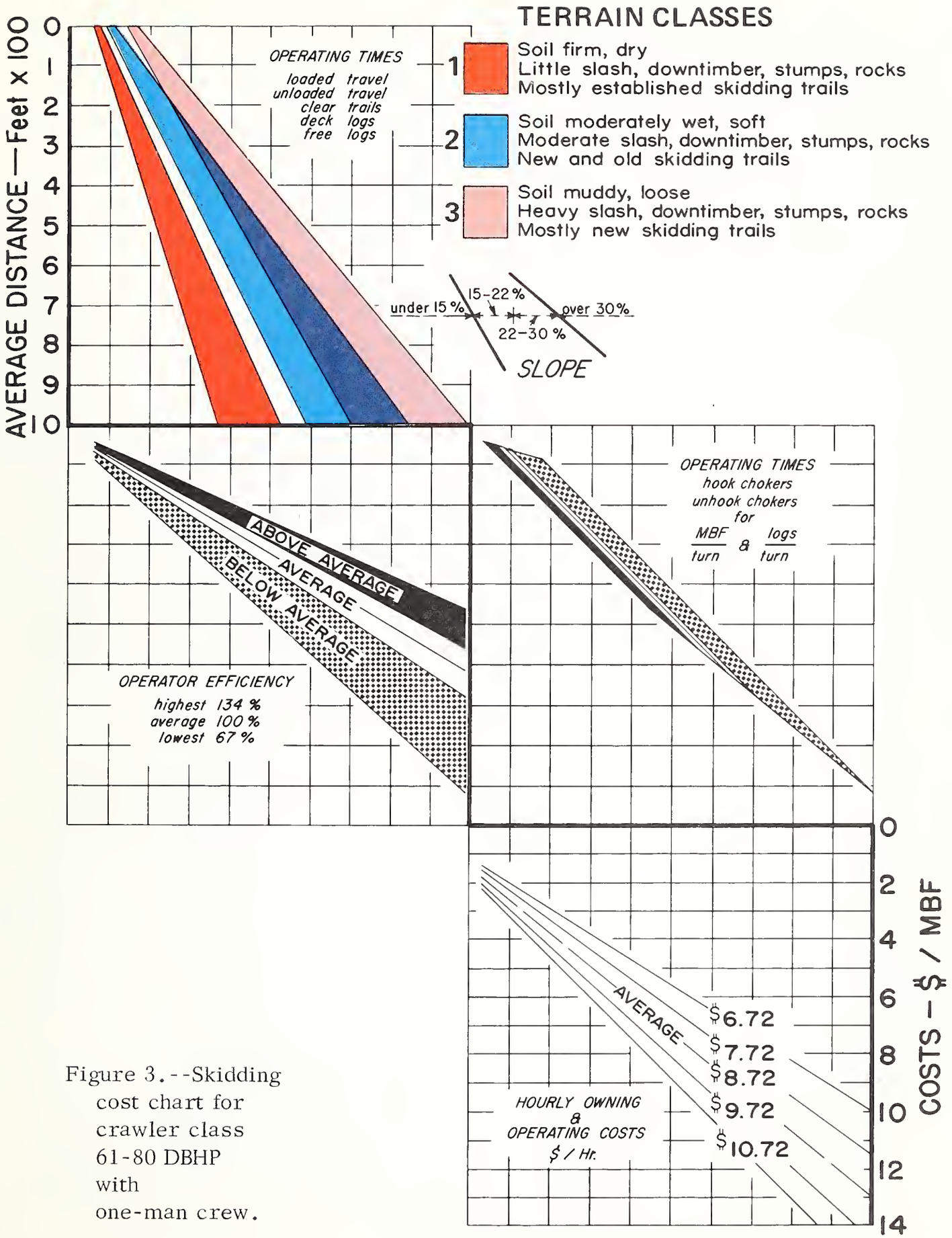

Figure 3.--Skidding cost chart for crawler class 61-80 DBHP with one-man crew.

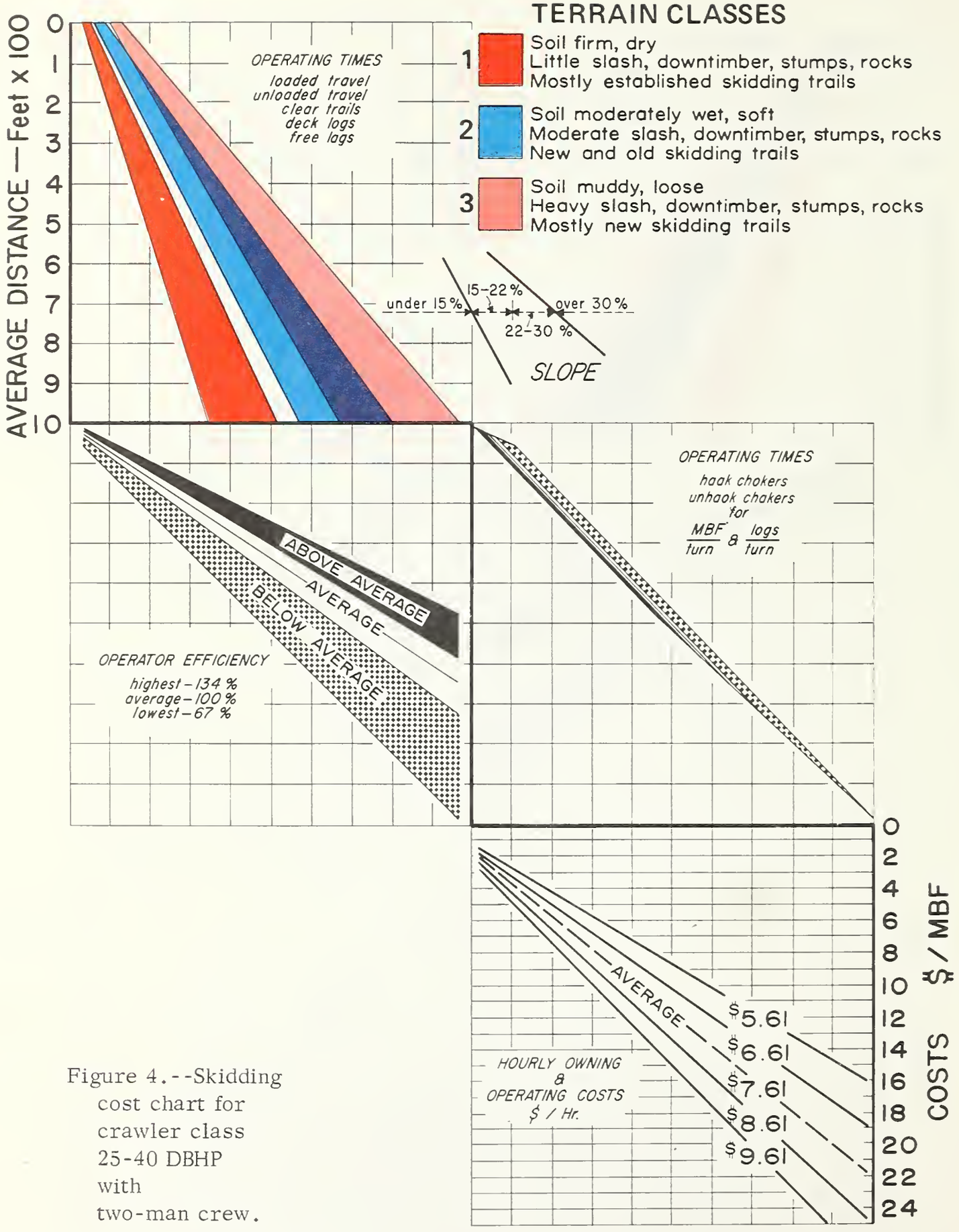

Figure 4.--Skidding cost chart for crawler class 25-40 DBHP with two-man crew.

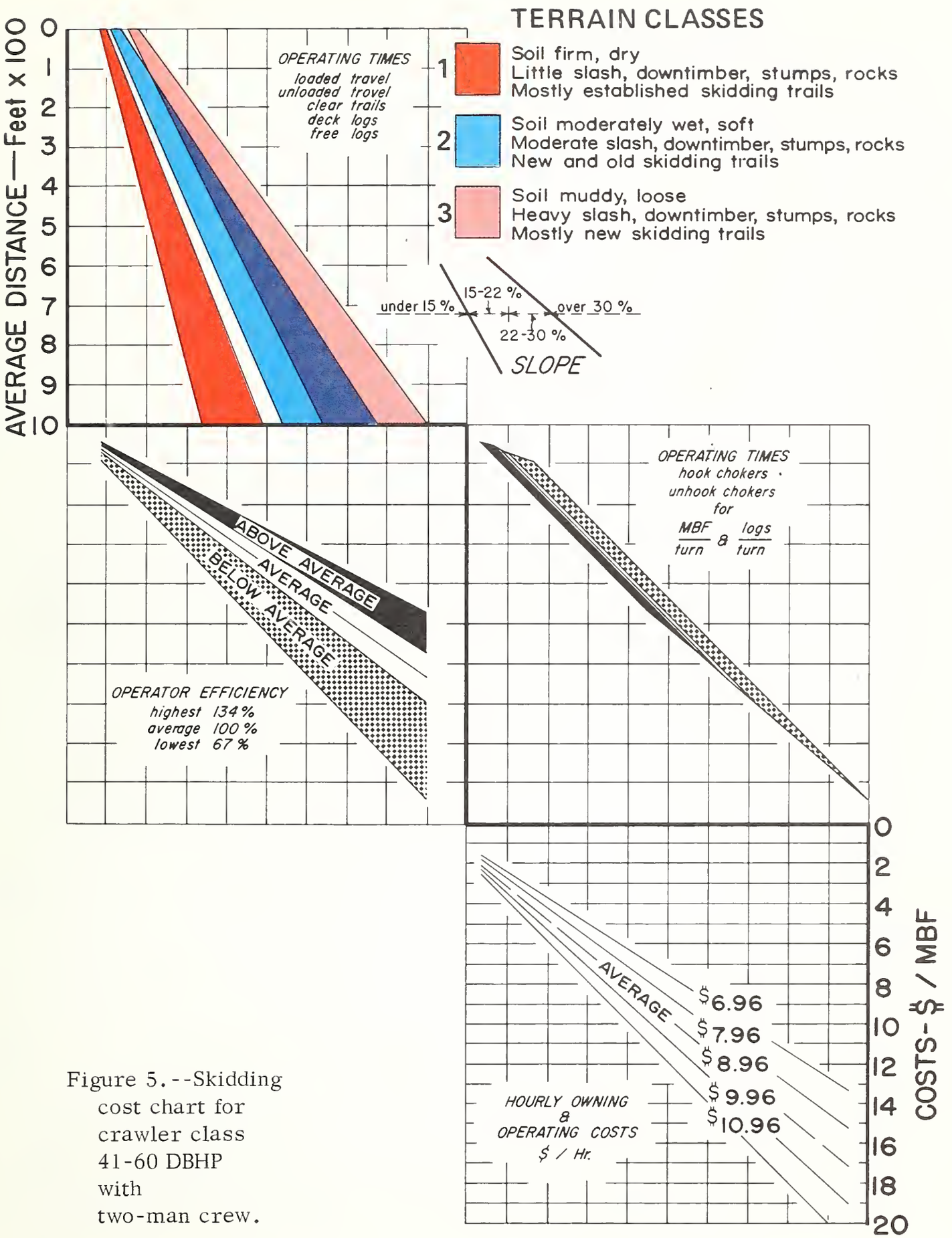

Figure 5.--Skidding cost chart for crawler class 41-60 DBHP with two-man crew.

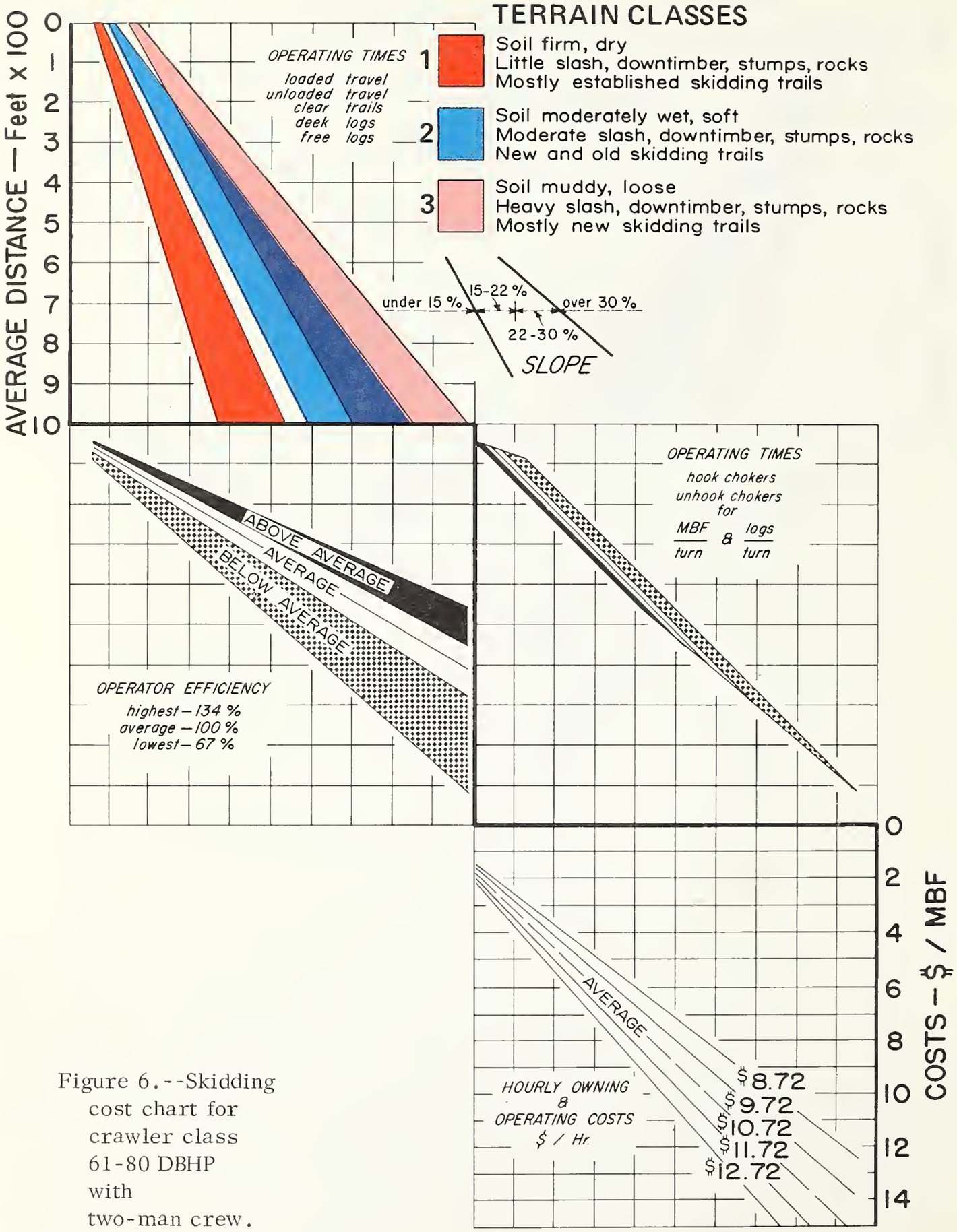

Figure 6.--Skidding cost chart for crawler class 61-80 DBHP with two-man crew.

OPERATING ALTERNATIVES

Figures 7 through 10 permit the contractor to rapidly determine the most economical combination of crawler and crew size for operating under ideal, average, and severe operating conditions for distances up to a thousand feet. These three operating conditions were defined as follows:

	Ideal	Average	Severe
Terrain class (as defined in figs. 1-6)	1	2	3
Slope	<15%	15-22%	>30%
Operator efficiency	110%	100%	90%
Hourly owning and operating costs:			
25-40 DBHP:			
One man	$4.61	$ 5.61	$ 6.61
Two men	6.61	7.61	8.61
41-60 DBHP:			
One man	5.96	6.96	7.96
Two men	7.96	8.96	9.96
61-80 DBHP:			
One man	7.72	8.72	9.72
Two men	9.72	10.72	11.72
Logs/turn:			
25-40 DBHP	4.044	4.044	4.044
41-60 DBHP	5.282	5.282	5.282
61-80 DBHP	6.711	6.711	6.711
BF/turn:			
25-40 DBHP	397	397	397
41-60 DBHP	487	487	487
61-80 DBHP	635	635	635
Log lengths	16-35 ft.	16-35 ft.	16-35 ft.
Log volumes	60-140 BF	60-140 BF	60-140 BF

Figure 7 shows that as operating conditions become worse for a one-man crew (no choker setter), the largest crawler class becomes and remains the most economical choice. Only under ideal conditions and for operations within 200 feet of the deck does the smallest crawler class appear slightly better than the largest. In figure 8 the largest crawler class is the best choice for a two-man crew (operator has a choker setter) without exception. Figure 9 shows that it is more economical to operate with

a one-man crew than with a two-man crew under average conditions; in short, a choker setter does not pay his own way under such conditions. Figure 10 shows where certain two-man crew operations are more economical than one-man crew operations. Specifically, a two-man crew using a crawler of the largest class costs less than a one-man crew using a crawler from either remaining class under average conditions for distances up to 350 feet. Also a two-man crew using the crawler of the largest class is better than a one-man crew using a crawler of the smallest class under severe conditions. Other trade-off comparisons may be seen by the user.

Those interested in applying results from this section are reminded that the trade-off areas are derived strictly from averages gained over a period of data gathering in the Forests mentioned earlier. This means that an experiment was not designed to give confidence limits on the results shown. Hence, trade-offs in figures 7-10 will no doubt deviate to some extent and should be used with caution.

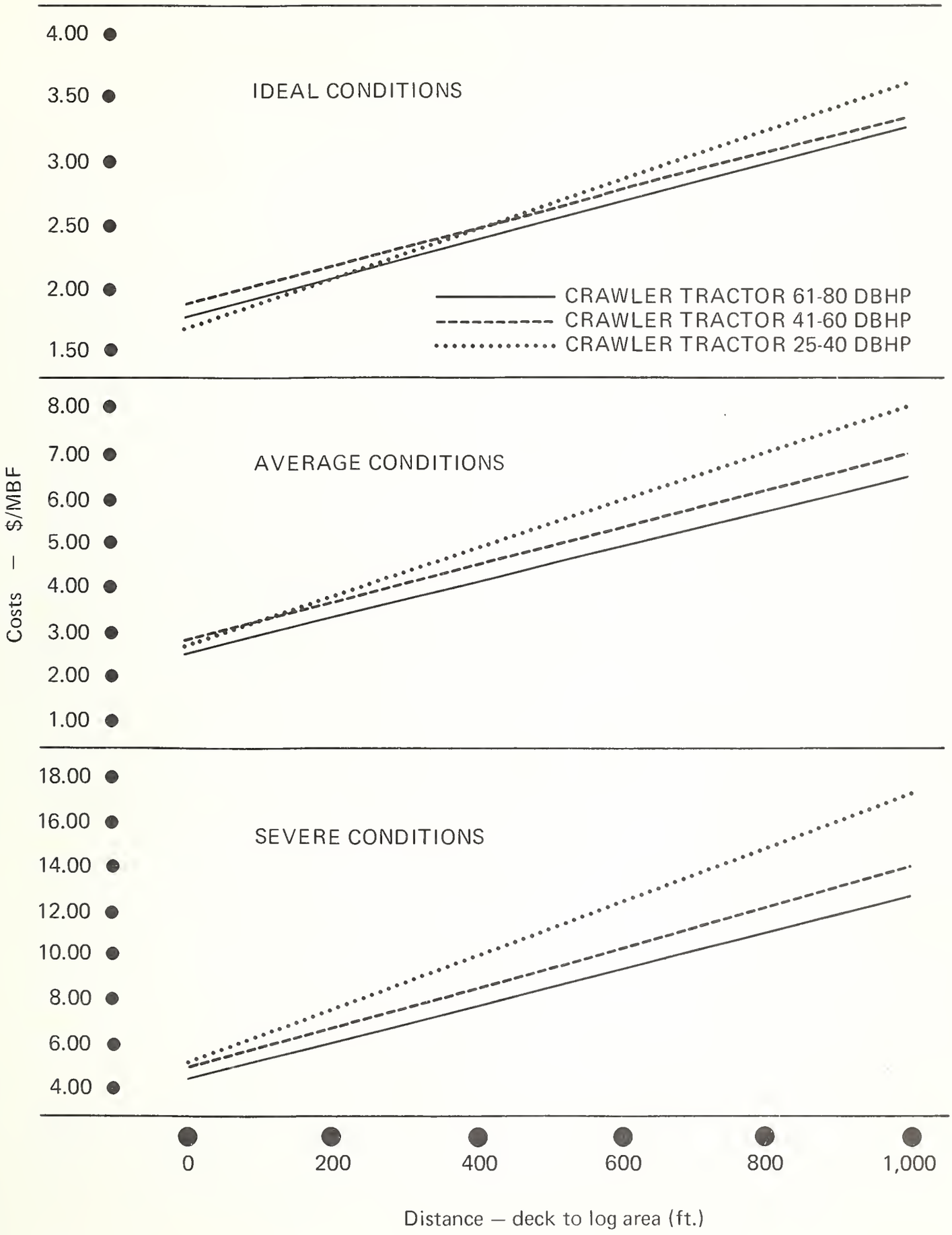

Figure 7.--Skidding costs under three defined operating conditions with one-man crew.

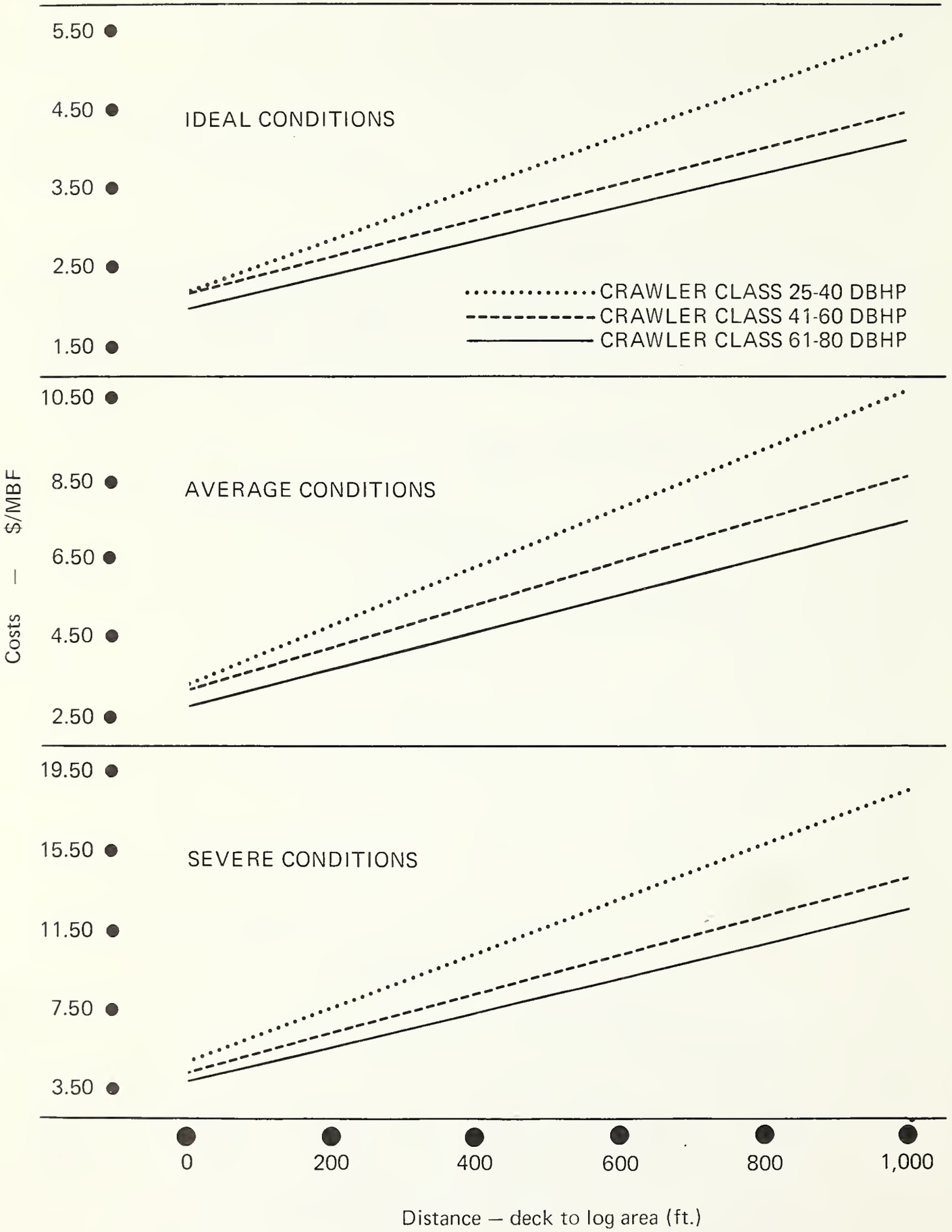

Figure 8.--Skidding costs under three defined operating conditions with two-man crew.

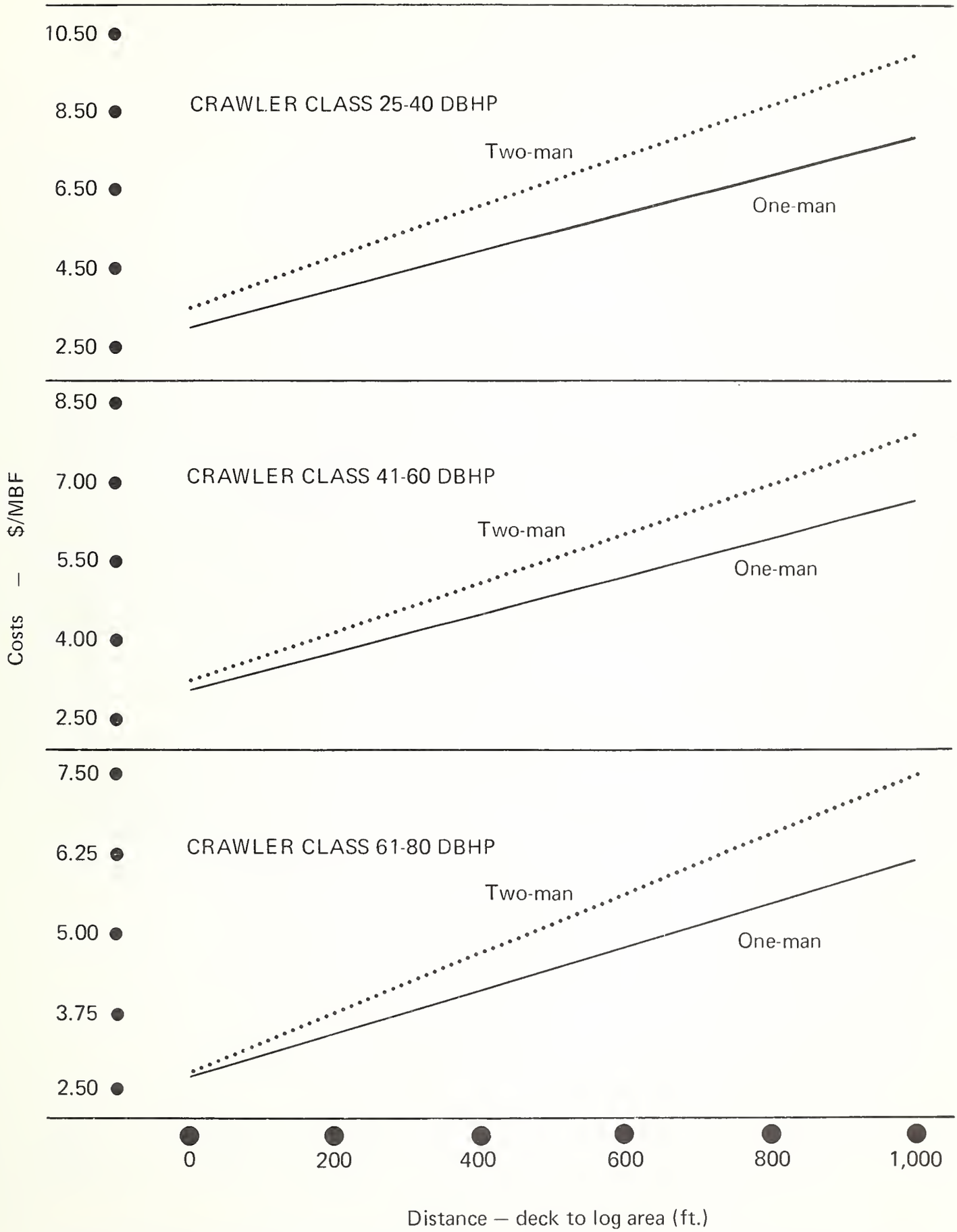

Figure 9.--Skidding costs under average operating conditions with both one-man and two-man crews.

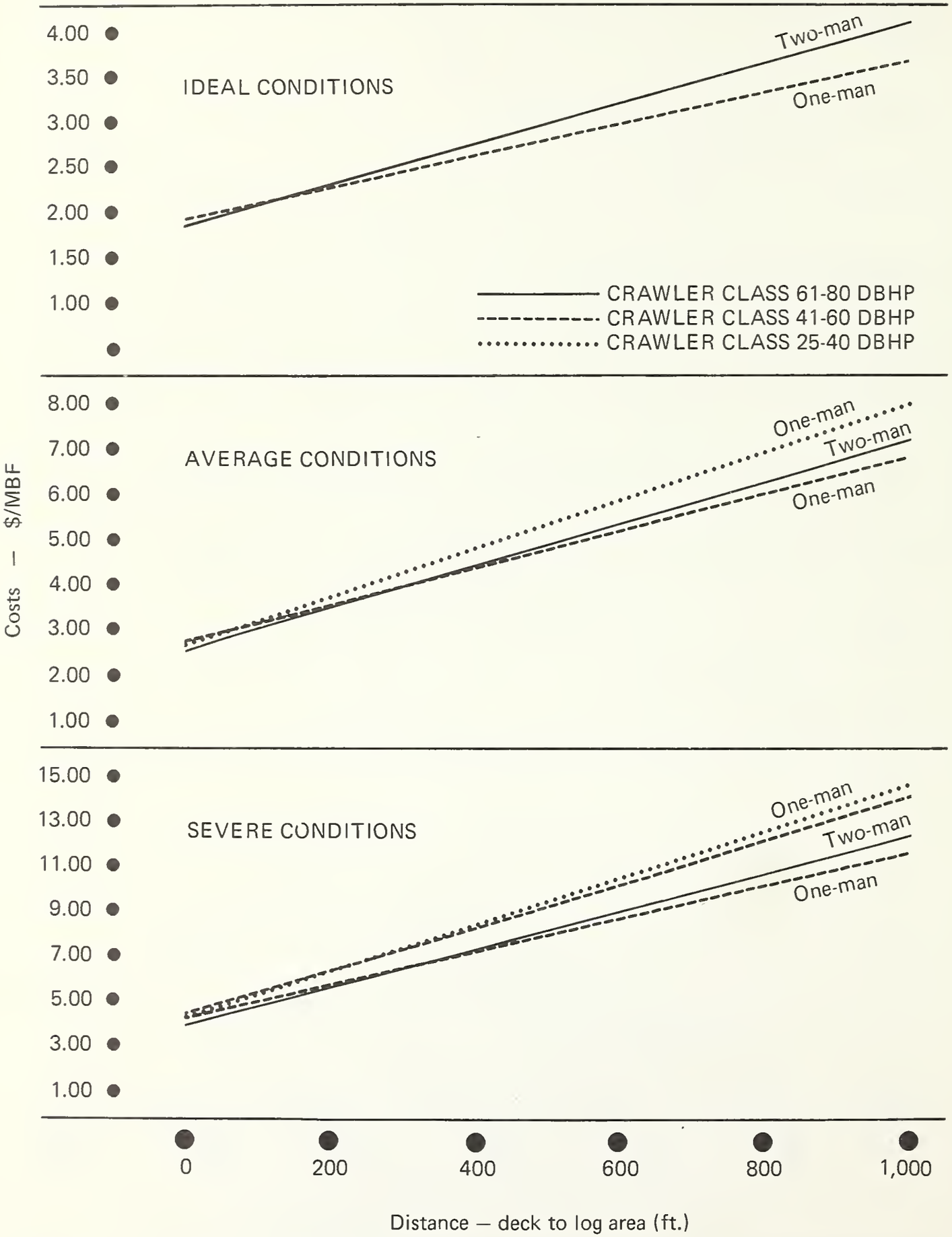

Figure 10.--Skidding costs under three defined operating conditions with both one-man and two-man crews.

APPENDIX

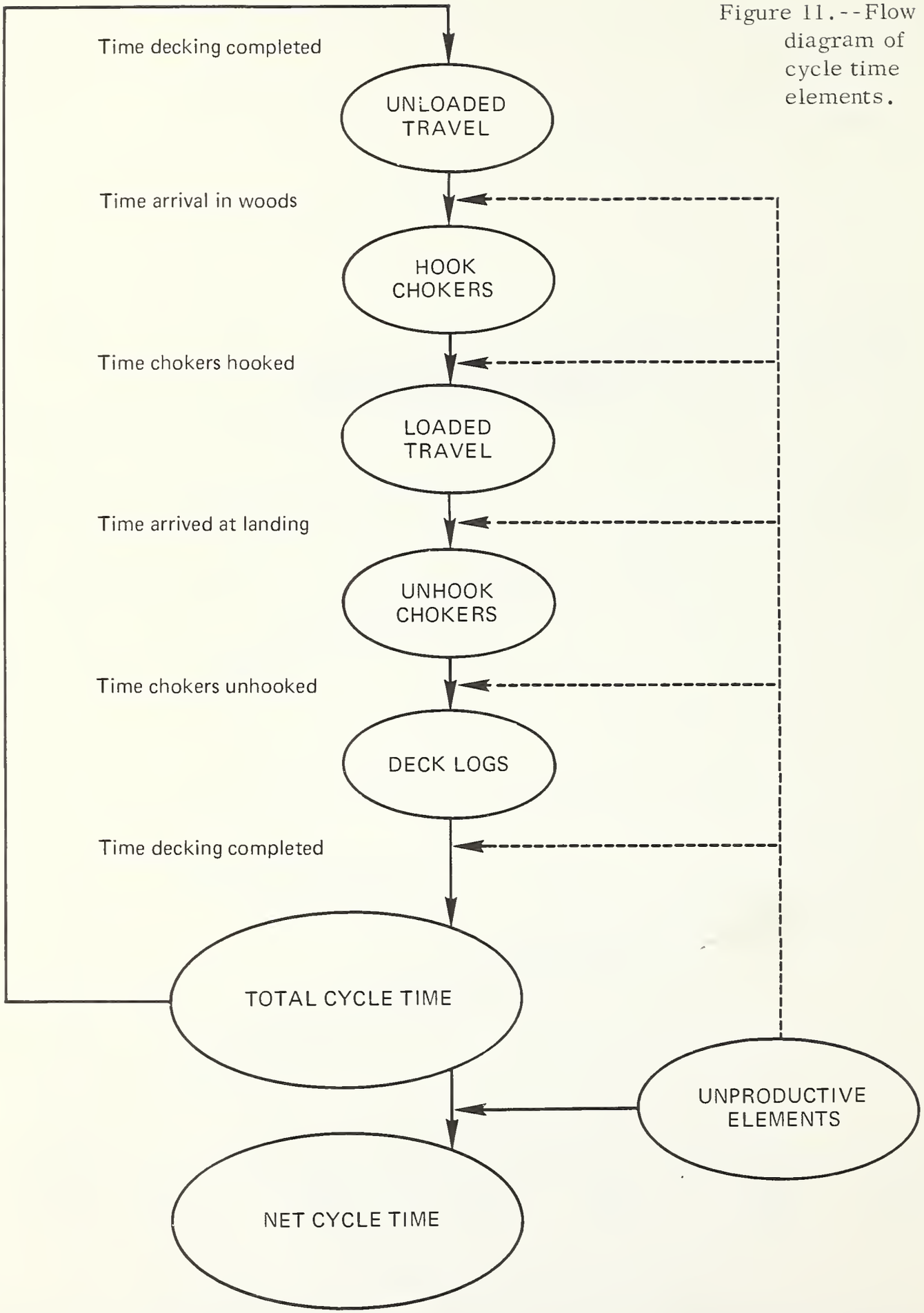

Figure 11.--Flow diagram of cycle time elements.

Cycle Time

The cycle time for crawler tractor skidding is illustrated by the flow diagram on facing page (fig. 11). Total cycle time consists of the accumulation of the five elapsed time intervals for the productive time elements shown in the smaller enclosures and the elapsed time intervals of unproductive time elements (includes delays resulting from equipment breakdown, personnel "breaks," adverse weather, etc.). The dotted lines are intended to indicate that such unproductive time elements might occur at any time during the cycle. Unproductive time elements must be subtracted from the total cycle time to get a net cycle time--the time considered for production rates. To the left of and straddling the five production elements are data commands. The elapsed time between two consecutive commands determines a time interval, providing the effect of unproductive elements is considered. A continuous decimal hour time study was used. For example,

Data command	Decimal hour
Time arrival in woods	0.0560
Time operator begins rest period	.0640
Time operator ends rest period	.0930
Time chokers hooked	.1170

Thus "HOOK CHOKERS" took 0.0610 hour total. Subtracting the unproductive time element "REST," which took 0.0290 hour, get 0.0320 hour net. Unproductive time element interruptions were defined as they occurred, recorded in the margins, and subtracted at the end of each day.

The following definitions assured standardization among data gathered by different people:

Data command	Definition
Time arrival in woods:	
One man	Operator dismounts crawler
Two men	Choker setter grasps winch or choker line
Time chokers hooked:	
One man	Operator mounts crawler
Two men	Last choker is hooked
Time arrived at landing	Operator dismounts crawler
Time chokers unhooked	Operator mounts crawler
Time decking completed	Crawler begins forward motion
Unproductive time elements	As observed, recorded separately

Under "OPERATING TIMES" in graphs 1 and 3 of the six charts, seven time elements are shown, five of which are the productive time elements shown in figure 11. The two remaining elements, shown in graph 1 of the charts, are "clear trails" and "free logs." Both began as unproductive time elements but eventually were considered productive and essential to the skidding operation; hence, they were added to cycle time. "Clear trails" is the time required to clear debris from skidding trails during each cycle. "Free logs" is the time necessary to winch logs clear of restraints.

Table 1.--Basic travel times per 50 feet increments[1]

Terrain class	Slope	Crawler class 25-40 DBHP		Crawler class 41-60 DBHP		Crawler class 61-80 DBHP	
		Unloaded	Loaded	Unloaded	Loaded	Unloaded	Loaded
	Percent	Hour					
Class 1							
	0-15	0.0045	0.0060	0.0042	0.0037	0.0041	0.0036
As defined in	15-22	.0053	.0071	.0050	.0044	.0049	.0044
figures	22-30	.0057	.0076	.0053	.0047	.0052	.0048
1-6	over 30	.0066	.0088	.0062	.0054	.0060	.0053
Class 2							
	0-15	.0073	.0097	.0068	.0060	.0066	.0058
As defined in	15-22	.0086	.0115	.0080	.0072	.0079	.0070
figures	22-30	.0092	.0122	.0086	.0077	.0084	.0076
1-6	over 30	.0110	.0142	.0100	.0088	.0097	.0085
Class 3							
	0-15	.0082	.0109	.0076	.0067	.0075	.0065
As defined in	15-22	.0097	.0130	.0091	.0080	.0089	.0078
figures	22-30	.0103	.0138	.0096	.0086	.0094	.0085
1-6	over 30	.0120	.0160	.0112	.0099	.0109	.0096

[1]Average times from 24 to 72 turns most situations. Interpolations made where data incomplete.

Controlling Variables

Cycle time variations respond to eight controlling variables. The variables are met as a user progresses through any of the charts. In graph 1, distance, terrain, and slope affect cycle time. Dropping down into graph 2, the fourth variable met is operator efficiency. In graph 3, MBF/turn (size of logs) and logs/turn (number of logs) tie down the production rate. The right combination of crawler class and crew size variables determine which chart to select.

Hourly Owning and Operating Costs

Hourly owning and operating costs are found in graph 4 on the charts. The costs are introduced in the last graph to translate production rates to production costs. These costs, which are shown on page 9, include total depreciation (initial cost less salvage value), interest, insurance, taxes, fuel, lubricants, repairs, parts, workmen's compensation, and operator's wages.

Constructing the Charts

Graph 1 is assembled from the following:

1. Arbitrary skidding distance scale (1,000 feet chosen for maximum conceivable distance).
2. Travel times under varying conditions of terrain, slope, and crawler size (table 1).
3. Average times to clear trails for three terrain classes defined in figures 1-6: class 1, 0.0057 hour; class 2, 0.0113 hour; and class 3, 0.0330 hour.
4. Average times to deck logs for different class crawlers: 25-40 DBHP, 0.0200 hour; 41-60 DBHP, 0.0166 hour; and 61-80 DBHP, 0.0161 hour.
5. Times to free logs (0.0101 hour per turn average regardless of crawler size).

In the following formula, all times are entered in decimal hours and all distances in feet. Results are in decimal minutes/turn with an allowance for distances spent maneuvering around landings.

[travel unloaded time + travel loaded time] [(1.2 X distance) + 120] +

[clear trail time + deck logs time + free logs time] 60 = minutes/turn.

Using this formula, the wedges shown in the first graph of each chart are set up throughout the range of distances and combinations of operating conditions for terrain and slope. The scale at the bottom of this graph has output values from the formula in minutes/turn. Actual output values from individual graphs are not shown until reaching the final chart output in $/MBF. Notice that choker handling times and log volumes, both of which are needed to complete the production cycle, do not appear in the first graph.

Graph 2 simply increases or decreases the output in minutes/turn from graph 1, according to the efficiency rating of the operator. Hence the output grid, located on the right border, is set up to accommodate the extremes of operator efficiency--from 67 percent under the most severe operating conditions to 134 percent under the most ideal. If an output value from graph 1 is 5 minutes/turn, it is upgraded to 4 minutes/turn when an operator receives a 125-percent efficiency rating; it is downgraded to 6.67 minutes/turn when an operator is about 75-percent efficient.

The formula for graph 2, in which operator efficiency is always entered in decimal form, follows:

[input minutes/turn (from upper grid)]/operator efficiency =
output minutes/turn (on right grid).

Graph 3 is assembled from

1. Average MBF/turn depending upon crawler class (tabulation, page 9).

2. Average number of logs/turn depending upon crawler class (tabulation, page 9).

3. Average times/log for handling chokers according to crawler class and crew size (table 2).

Table 2.--Average times per log for handling chokers

Crawler class	Crew size	Choker operation	
		Hooking	Unhooking
		Hour	
25-40 DBHP	One man	0.0216	0.0066
	Two men	.0172	.0044
41-60 DBHP	One man	.0190	.0059
	Two men	.0151	.0038
61-80 DBHP	One man	.0138	.0045
	Two men	.0110	.0030

Total cycle time is found by

$$[\text{logs/turn}][\text{hook chokers time} + \text{unhook chokers time}]\frac{60}{\text{operator efficiency}} +$$

minutes/turn (from left grid),

where choker handling times are entered as decimal hours. The bottom grid must have a production rate output in minutes/MBF; thus divide the total cycle time by turn volume to complete graph 3, or

1,000[total cycle time (from above)]/BF/turn = minutes/MBF.

Graph 4 takes the outputs from graph 3 on the upper grid, combines them with the costs corresponding to the proper crawler sizes (tabulation, page 9), and converts production rates to a measure of effectiveness in $/MBF, or

[minutes/MBF(output from graph 3)][hourly owning and operating costs]/60 =
$/MBF (chart output).

Of course, averages in any of the four graphs on each chart may be changed to suit user modifications. Beginning at the point of modification, output grids must be revised until a new output grid for each chart in $/MBF is attained.

Schillings, Paul L.
1969. Selecting crawler skidders by comparing relative operating costs. U.S. Dep. Agr., Forest Serv., Intermountain Forest and Range Exp. Sta., Ogden, Utah 84401. 20 pp., illus. (USDA Forest Serv. Res. Pap. INT-59)

Costs of skidding with 25- to 80-drawbar hp. crawler tractors in southwestern Montana are analyzed and compared. Data include operating times, terrain classes, steepness of slopes, efficiency of operators, costs of owning and operating, and log production. Charts enable a user to quickly estimate skidding cost per MBF considering distance from log deck to log-making area, type of terrain, average slope, and efficiency of operator.

Schillings, Paul L.
1969. Selecting crawler skidders by comparing relative operating costs. U.S. Dep. Agr., Forest Serv., Intermountain Forest and Range Exp. Sta., Ogden, Utah 84401. 20 pp., illus. (USDA Forest Serv. Res. Pap. INT-59)

Costs of skidding with 25- to 80-drawbar hp. crawler tractors in southwestern Montana are analyzed and compared. Data include operating times, terrain classes, steepness of slopes, efficiency of operators, costs of owning and operating, and log production. Charts enable a user to quickly estimate skidding cost per MBF considering distance from log deck to log-making area, type of terrain, average slope, and efficiency of operator.

Schillings, Paul L.
1969. Selecting crawler skidders by comparing relative operating costs. U.S. Dep. Agr., Forest Serv., Intermountain Forest and Range Exp. Sta., Ogden, Utah 84401. 20 pp., illus. (USDA Forest Serv. Res. Pap. INT-59)

Costs of skidding with 25- to 80-drawbar hp. crawler tractors in southwestern Montana are analyzed and compared. Data include operating times, terrain classes, steepness of slopes, efficiency of operators, costs of owning and operating, and log production. Charts enable a user to quickly estimate skidding cost per MBF considering distance from log deck to log-making area, type of terrain, average slope, and efficiency of operator.

Schillings, Paul L.
1969. Selecting crawler skidders by comparing relative operating costs. U.S. Dep. Agr., Forest Serv., Intermountain Forest and Range Exp. Sta., Ogden, Utah 84401. 20 pp., illus. (USDA Forest Serv. Res. Pap. INT-59)

Costs of skidding with 25- to 80-drawbar hp. crawler tractors in southwestern Montana are analyzed and compared. Data include operating times, terrain classes, steepness of slopes, efficiency of operators, costs of owning and operating, and log production. Charts enable a user to quickly estimate skidding cost per MBF considering distance from log deck to log-making area, type of terrain, average slope, and efficiency of operator.

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

Boise, Idaho
Bozeman, Montana (in cooperation with Montana State University)
Logan, Utah (in cooperation with Utah State University)
Missoula, Montana (in cooperation with University of Montana)
Moscow, Idaho (in cooperation with the University of Idaho)
Provo, Utah (in cooperation with Brigham Young University)

FOREST SERVICE CREED

The Forest Service of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing nation.